

**FNAS CRRES Program Completion**

**Final Report on NAS8-38609  
Delivery Order #60**

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## **Introduction**

The tasks undertaken to be performed under this contract included the continued coordination and documentation of the CRRES program and the development of an archive that details the experimental results obtained by the CRRES Program. Details of the work undertaken and results achieved are summarized in the following sections.

### **The Final CRRES IWG Meeting**

The Program Coordinator, working in conjunction with the Program Manager, Program Scientist, Technical Monitor, Principal Investigators and SAIC organized the final CRRES IWG Meeting for the CRRES Satellite, PEGSAT, Kwajalein and El Coqui rockets. This meeting was held at SAIC, 1710 Goodridge Drive, McLean Virginia, 12/14 through 12/16/92. A copy of the agenda and a list of the personnel that participated is included at the end of this report. Also included are summaries of key issues discussed. These included:

A discussion of El Coqui Science Issues (93-94) by Frank Djuth. (Appendix A)

A review of Caribbean and CIV Releases (G1 - G9, G11A - G13) by Hans Nielsen. (Appendix B).

A review of High Altitude Releases by Steve Mende. (Appendix C)

A discussion was also undertaken with special regard to CRRES data analysis and the future of support for active experiments. This resulted in statements in support of active experiments and a request to maintain the Puerto Rican launch capacity. A letter was draft to Dr. George Withbroe/NASA Headquarters in support of additional funding for data analysis for the NASA CRRES PIs. (Appendix D).

### **CRRES Archiving.**

The Principal Investigator delivered copies of the CRRES Program Directory to the Experimental Principal Investigators present. Missing areas of data remaining in the archive were identified and it was decided that corrections were to be delivered to the Principal Investigator by January 15, 1993..

A copy of the archive presented at the meeting is included in the Final Report in Appendix E.

CRRES IWG MEETING  
DECEMBER 14-15, 1992  
AGENDA

MONDAY DECEMBER 14

9:00 - 9:15	Greetings/Introductions/Logistics	R. Howard/ M. Alzmann
9:15 - 10:00	Message from Headquarters <ul style="list-style-type: none"> <li>- Space Physics Division and OSSA</li> <li>- CRRES FY93 Budgets</li> <li>- Program Summary Data Book/NSSDC</li> <li>- Summary of Russian Observations</li> </ul>	R. Howard
10:00 - 11:00	Open Discussion - Lessons Learned Assessment of CRRES Program <ul style="list-style-type: none"> <li>- Management/Campaign Planning and Operations/Site Effectiveness/ Data Collection and Distribution/ Science Return/Data Analysis</li> </ul>	All
11:00 - 12:00	Open Discussion - What Next? Future of Active Experiments <ul style="list-style-type: none"> <li>- Plans for AGU Sessions/Other Meetings</li> <li>- NASA Opportunities</li> <li>- Position on Active Experiments in Space</li> <li>- Back to Arecibo?</li> </ul>	
12:00 - 1:00	Lunch Break	
1:00 p.m.	Nostalgic Tour Through CRRES	M. Alzmann
1:15 p.m.	Optical Observations High Altitude Releases	S. Mende
1:30 p.m.	Wave Observations of High Altitude Releases (G-2 - G-8, and G-10)	R. Anderson
1:45 p.m.	G-10/G-9	M. Pongratz
2:00 p.m.	Caribbean Releases G-12, G-13 and G-14	H. Nielsen
2:15 p.m.	Ion Composition Observations of G-11B	D. Hunton
2:30 p.m.	Observations and Modeling of G-1, G-9, G-10 and G-12	A. Valenzuela/ H. Frey
2:45 p.m.	Skidding in G-9	J. Huba
3:00 p.m.	Skidding in the G-2 Release	P. Bernhardt
3:15 p.m.	"In situ" E-Field and Wave Observations	J. Wygant
3:30 p.m.	Kwajelein Results	M. Mendillo
3:45 p.m.	Overview of AA-1 and AA-7	K. Groves
4:00 p.m.	AA-4 Objectives and Preliminary Results	P. Bernhardt

4:15 p.m.	Multi-Ion Expansions in AA-3B	E. Szuszczewicz
4:30 p.m.	Radar Observations during AA-1, -2, -3B, -4, and -7	F. Djuth
4:45 p.m.	Rocket Observations of Chemical Releases at Kwajelein	R. Pfaff
7:00 p.m.	Business Dinner	

## TUESDAY, DECEMBER 15

9:00 - 12:00	Open Forum Discussions A. Future of Active Experiments B. Interesting Concepts For Chemical Release Experiments in Space C. Future CRRES Meetings and Approaches to Extended Support	
12:00 - 1:00	Lunch Break	
1:00 - 3:00	Splinter Group Meetings A. High Altitude Releases B. LEO Releases C. Rocket Campaigns D. Letter to Headquarters	S. Mende H. Nielsen F. Djuth E. Szuszczewicz/ M. Pongratz
3:00 - 5:00	Report and Discussions of Splinter Group Meetings	
5:00	Adjourn	

# CRRES Meeting 12/14/92

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## **Appendix A**

### **EL COQUI KEY SCIENCE ISSUES (93-94)**

By Frank Djuth

- HF-induced ionospheric structures - observations at unprecedented resolution and capable of resolving competing theories
- Fundamental HF wave-plasma interactions in Ba<sup>+</sup>: Inconsistency with all existing theories
- Negative ion chemistry and modeling
- Long-lived enhanced T<sub>e</sub>, Barium ions
- Multi-ion expansion physics: Kinetic and electrodynamic coupling processors

## **Appendix B**

### **REVIEW OF CARIBBEAN AND CIV RELEASES (G1 - G9 - G11A - G11B - G12 - G13 - G14)**

By Hans Nielsen

#### **I. SCIENTIFIC OBJECTIVES:**

- Critical Velocity Ionization
- Diamagnetic Effects (Skidding)
- Differential ion Expansion
- Field-Line Equipotentiality
- Plasma Effects on Distribution Functions

#### **II. SUCCESS OF EXPERIMENTS**

- All releases performed according to plan
- Minimum success criteria exceeded for all releases
- High quality data obtained from radar
  - Ground-based and airborne optical instruments in both hemispheres
  - In-situ particle and field instruments

#### **III. ACCOMPLISHMENTS TO DATE:**

- Data from individual groups have been reviewed, catalogued and quality assessed.
- Start of analysis of individual data sets with some intergroup collaboration

#### **IV. SCIENTIFIC HIGHLIGHTS PRESENTED AT MEETING:**

- Theoretical emission rates confirmed
- Skidding observed and modelled
- Non-photoionization (CIV?) observed
- Conjugate equipotentiality also at plasma reversal time
- Modification of velocity distribution function
- New charge-exchange and momentum transfer cross sections
- Ion clouds observed more than 10 hours after release

Based on individual data sets many conference presentations have been given and a number of referenced journal publications are in print. These have shown the beginnings of an understanding of the physics issues we set out to investigate. They have also shown a number of unexpected results (e.g., apparent collisionless expansion of a release, long lived (>10 hours) ion clouds).



In order to exploit fully this complex and rich CRRES dataset it is clear that a great deal of further computer modelling, data exchange and analysis among all investigations will be required. Thus we see a clear need for a continuation of the data analysis phase of the CRRES program for at least another 2 years.

## Appendix C

### REVIEW OF HIGH ALTITUDE RELEASES

By Steve Mende

#### I. SCIENTIFIC OBJECTIVES:

1. Interaction of plasma clouds with the ambient magnetospheric plasmas, diamagnetic cavity formation, electric field penetration, wave production, instabilities.
2. Seeding the magnetosphere to produce precipitation.
3. Collisional interactions in the ionosphere including ambipolar effects.

#### II. SUCCESS OF EXPERIMENTS:

1. Most complete data set ever. Well instrumented spacecraft. Excellent ground observations.
2. Mixed results (model tests).
3. Unexpectedly low interactions with ambient atmosphere (models?).

#### III. INVESTIGATOR NEEDS AND COMMENTS

##### G-1

Morrie wants: FP data from Lockheed Southern hemisphere data  
MPE wants: Orbit data, injection pitch angle, early time data from Morrie  
Wygant wants: High res. early time data from Morrie  
MPE wants: Ionospheric data from Arecibo  
Los Alamos wants: Ionospheric data from Duncan?

##### G-2

Good use for ionization study  
Morrie wants: Mary's histogram  
GSFC wants: NRL data from Bernhardt  
GSFC wants Spacerad data  
Roger wants 1st 2 minutes  
Study: Size and length of cavity (Hoffman)  
Study: Deceleration of cloud (Mende)  
Wygant provides summary plots  
Roger wants image/40 minutes after release pictures? from GSFC

### G-3

GSFC doing  $\Delta$ -tion  
Station Shortage  
GSFC wants data from MPE (El Leoncito)  
Wygant wants 1 picture - 1st - 20 sec.  
Roger wants picture of 2 minutes  
Study: Electric field in-out cloud (John)  
Structuring, is it spatial? (John)  
Low frequency turbulence related cloud (Roger)  
Collisionless deceleration of cloud (John, Mende)  
Magnetosonic waves (Singer)

### G-4

Optical data

White Sands  
El Leoncito  
Florida

GSFC will do it but when they have time  
GSFC wants MPE data  
Wygant wants 1-4 minutes  
Roger wants LANL data

### G-5, G-6, G-7

Discussion of releases in terms of wave activity (Roger)  
Electric fields at leading edge. Expansion of plasma. (Wygant)  
Mende wants Hardy's data  
MPE wants GSFC data  
MPE wants data from Wygant

### G-8

GSFC wants times from Lockheed  
1 per 5 minutes and Arecibo data  
Wygant wants (when s/c leaves cloud) pictures (20 min.)  
MPE wants electron density  
GSFC wants MPE data  
Scientific topics:  
Expansion of collisionless plasma  
Diamagnetic cavity  
"Electrostatic cavity" deceleration of cloud  
Did we start aurora?

G-10

MPE did triangulate

Lockheed will triangulate if needed (Florida)

Same applies as G-8

## Appendix D

### Support for Active Experiments

Research announcements of the NASA Space Physics Supporting Research and Technology, Suborbital, and Theory Programs have for the past three years emphasized the study of natural plasma processes in the space environment, advising that "basic plasma physics experiments that are made possible simply by access to space may be supported, but at a distinctly lower priority as funding permits." In times of increasing competitive pressures on NASA space research programs, this essentially eliminates exploiting the near-Earth space environment as a natural plasma laboratory-without-walls, depriving NASA of the participation of a substantial scientific research community.

The use of near-Earth space as a laboratory is a fundamental component of the charter of NASA's Office of Space Science and Applications. Near-Earth space serves as a platform for investigations of astrophysics and solar system science, for study of the Earth, and for development of applications in communications and information systems. OSSA also exploits the near-Earth space environment as a laboratory for investigation of fundamental processes in life sciences, materials science, microgravity research, and the development of advanced electronics. It is disappointing that the Space Physics Division has chosen not to incorporate the recommendations of the most recent National Research Council study of Plasma Sciences, but continues explicitly to emphasize programmatic goals to the exclusion of work supporting progress in broader fundamental disciplinary studies. The CRRES IWG urges NASA Space Physics Division to reconsider its present policy of discouraging many active space experiment opportunities, and instead to encourage the full participation of the Active Experiments research community in future research planning and implementation activities, with proposed research appraised on scientific merit and without arbitrary bias to the fundamental or applied nature of the respective studies.

## **Request for Maintaining Puerto Rico Launch Capability**

The CRRES Investigator Working Group hereby requests that NASA Headquarters take whatever official actions are required so as to maintain the opportunity for future sounding rocket campaigns in Puerto Rico using the launch facilities developed for CRRES. The acquisition and preparation of these facilities required considerable time and effort, even to the degree of causing a nine month delay in the sounding rocket campaign. The opportunity to continue periodically launching sounding rockets in Puerto Rico, in conjunction with use of the powerful atmospheric diagnostic facilities of the National Astronomy and Ionosphere Center (Arecibo Observatory), represents an experimental capability that should be retained for future investigators.

At this early stage of CRRES data analysis, the research community is unprepared to submit a formal campaign proposal for a return to Puerto Rico. However, we are convinced that such a campaign proposal may be organized at the appropriate time, based upon both the quality of our preliminary results from CRRES and the many expressions of interest in participation in future campaigns by other scientists. Even with limited advance notice two of the rockets in the recent campaign were non-CRRES investigations. A substantial segment of the sounding rocket investigator community was unable to participate in the campaign within the constraints of the available schedule. It would be an administrative oversight to allow this promising experimental capability to be lost to future investigations.

Draft letter to Dr. George Withbroe/NASA Headquarters

Prepared by: E. Szuszczewicz and M. Pongratz

(This draft is largely identical to that reviewed during the IWG. Some typographical errors have been removed, "unresolved issues" have been slightly modified, and text has been included under "request". Suggested changes already submitted by IWG members are on file for synthesis with all inputs.)

Dear Dr. Withbroe:

## I. Summary

NASA's CRRES Program began in 1981 as a joint NASA/USAF endeavor to meet the objectives of three investigations: NASA/CRM, USAF/SPACERAD and NAVY/LASSII. The history of the effort has been mixed with problems and blessings; and has gotten to its current level of success only through the commitment of NASA and the Air Force, and the dedication of the CRRES science team. The initial payload was to fly on the Challenger Shuttle mission. Following the accident the program (**number of PI's?**) was rescoped to involve Satellite and sounding rocket releases that included "in situ" measurements with extensive radar support and ground and aircraft based optical diagnostics. The satellite portion of the program has had a very successful 13 month lifetime, having released all the canisters in planed scenarios involving the magnetospheric and ionospheric domains. Battery failure caused a premature end of the program in October, 1991. Those elements of the program off loaded from the satellite mission because of the Challenger disaster were largely accommodated in the Kwajelein and Puerto Rican sounding rocket campaigns. On this occasion of our last scheduled CRRES working group meeting we face the awkward situation of program termination at a time when all the data and the analysis techniques are only just coming into place. While all experimental aspects were executed according to plan, the analysis have only begun, with only initial successes in having met the scientific objectives. Unique features of this program include four major components with degrees of participation unmatched in any previous NASA effort. These components include a sophisticated and complex coordination effort involving the releases themselves, "in situ" measurements, remote diagnostics by radars and optical sensors, and the development of large-scale numerical models. Our multi-parameter, multi-

platform data base has completely defined the prevailing conditions in the natural system at the time of each release and the expansion and coupling phenomenologies at very early, mid-term and late times. The complexity of the data base matches the challenge of the investigation and the program plans as laid out nearly a decade ago. The models themselves play an important role in analyzing the complexities of the expansion and coupling processes and their relationships to phenomena in the solar terrestrial system. In some regards this coordination is the first of its kind. It represents a new and important era for NASA investigations and its concept is embodied in the TIMED mission. At this, our last scheduled CRRES scientific working group meeting, we find ourselves on the threshold of a productive period of data reduction and analysis all geared to a proper achievement of originally stated scientific objectives. We are at a stage now where the data products have only just come into place and the models have sufficiently matured to execute a proper and effective analysis. To bring this about it is necessary to extend NASA support for an additional two years. Such an extension is in keeping with recent satellite programs where satellite data analysis has always proceeded for a minimum of three years, including the operation phases. It is only with this extension that the full objectives of the CRRES program can be met.

## **II. Science Objectives**

The objectives of CRRES were focused on controlled experiments that could test developing models and concepts of plasma coupling mechanisms in the solar terrestrial system. Many aspects of the CRRES releases mimicked such phenomena as solar flare expansions, the evolution of coronal mass ejections, polar wind flow, Interhemispheric coupling in the ionosphere, fluxtube refilling after storms, the stable trapping limit, kinetic and electrodynamic coupling in the ionospheric-thermospheric system, geoplasma instability processes, and the triggering of equatorial spread-F.

## **III. Wealth and Complexity of Data**

The database defines the input and output terms, and all intervening processes. We have "in situ" and remote sensing measurements that are both satellite borne and ground based. These data are in scalar, vector and image formats, and



require carefully detailed efforts involving spatial and temporal co-registration and comparisons with model outputs. The formatting and analysis of the data also involves the coordination of nearly 15 different research groups distributed throughout the world.

#### **IV. Analysis to Date**

At this time we have only begun what qualifies as the initial phases of our analysis and publication efforts with the bulk of our current list of publications best described as "preliminary findings". The "in situ" measurements are only now coming into the hands of the entire science team and the coordination with ground based optics and radars has just emerged from its embryonic stages.

#### **V. Unresolved Issues**

We have yet to scratch the surface of the fundamental issues that involve each and every release in the campaign. As examples of some of the outstanding questions to be resolved we include the following list: Does the CIV process work? Under what conditions are field lines equipotentials? Can the auroral precipitation process be triggered? What mechanisms cause and damp turbulence in space plasmas? What are the relative roles of collisions, diamagnetism, instabilities and ambipolar diffusion in modifying velocity distribution functions? How do the wave and particle distributions evolve in space and time as the expanding cloud couples to the background geoplasma domain?

#### **VI. Request**

We request that the Space Physics Division make available two additional years of funding for continued data reduction and analysis. We also request that this funding be made available as quickly as possible in order to maintain continuity of the investigations. We estimate that \$1.5M for each of two years is an adequate level of support. We suggest that these funds be reserved solely for support of proposals from the NASA CRRES PIs, and that these proposals be limited to the objectives of the original science plan and associated science team.

NASA

National Aeronautical and  
Space Agency

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